Predicting Trophic Interactions and Habitat Utilization in the California Current Ecosystem

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LONG-TERM GOALS

While specifically focusing on trophic interactions affecting habitat utilization and foraging pattern of sea lions in the California Current Large Marine Ecosystem (CCLME), the long-term goal of our

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modeling approach is to better understand and characterize biological "hotspots" (i.e., the aggregation of multiple marine organisms over multiple trophic levels) off the U.S. west coast and in other regions where similar fully-coupled ecosystem models may be implemented (e.g., Southern Ocean). As such, our research represents a major step towards a predictive model that can provide fundamental knowledge about: (1) the spatial and temporal distribution of key marine organisms over multiple trophic levels, and (2) natural and anthropogenic variability in ecosystem structure and trophic interactions

OBJECTIVES

The main research objective is to quantify habitat utilization and trophic interactions in the CCLME by considering patterns of covariability between environmental variables (e.g., temperature, primary production) and foraging patterns and success of middle (forage fish) and higher (sea lions) trophic level organisms. Since our numerical experiments are designed to isolate patterns of variability on seasonal to interannual timescales during "normal" and "extreme" years, we focus our analysis on identifying shifts in habitat utilization (e.g., shelf vs. offshore foraging) in the CCLME. We will also explore which features and environmental properties control foraging success in different sub-regions of the CCLME (e.g., onset and duration of upwelling season on the shelf, eddy variability and wind stress curl offshore).

APPROACH

Our fully-coupled ecosystem modeling framework consists of a lower trophic level ecosystem model (NEMURO) embedded in a regional ocean circulation model (ROMS), and both coupled with a multi-species individual-based model (IBM) for forage fish and higher trophic level species. The IBM for forage fish focuses on adult populations of two coastal pelagic species (sardines and anchovies), with growth based on bioenergetics, temperature and prey (i.e., plankton) generated from the ROMS and NEMURO models. The IBM for higher trophic level predatory species focuses on the implementation of a bioenergetics and behavior model for California sea lions by using available data on their foraging patterns and diet in the CCLME. Individuals in the IBMs are followed on the same spatial grid as used for the ROMS and NEMURO models, and movement is based on algorithms that attempt to represent the behavior of the individuals. The numerical experiments with the fully-coupled ecosystem modeling framework are designed to identify patterns of trophic interactions and habitat utilization on various timescales, including periods of extreme variability such as El Niño or La Niña events. By implementing several behavioral algorithms with different foraging cues, we will explore the robustness of the results under various environmental conditions. This information will eventually lead to understanding the level of accuracy with which the occurrence of biological "hot spot" in the CCLME can realistically be predicted.

Our team is well qualified to achieve the research objectives, with expertise in areas including climate modeling in upwelling regions (Enrique Curchitser at Rutgers), physical-biological modeling in the California Current (Jerome Fiechter and Christopher Edwards at UCSC), data assimilative methods (Andrew Moore at UCSC), forage fish ecology and bioenergetics (Kenneth Rose at LSU), and pinniped ecology and bioenergetics (Daniel Costa at UCSC). In addition to the PIs, a postdoctoral research associate (Luis Huckstadt at UCSC) was added to the team to develop the bioenergetics and behavior components for the California sea lion IBM under the supervision of co-PI Costa. Finally, several members of the team have already been collaborating for the last few years under various NSF and NOAA funded research projects.

WORK COMPLETED

Even though the original project start date was April 2012, delays in processing the award at UCSC resulted in funds only made available to the PI Fiechter in August 2012. Consequently, work on the award was not started until September 2012. In the first month of the award, PI Fiechter, co-PI Costa and post-doctoral researcher Huckstadt met to establish the guidelines for implementing the California sea lion bioenergetics and behavior components of the model. The bioenergetics component will be first developped for adult males and focus on the trade-off between energy gains form successful feeding and energy expenditures related to short- vs. long-distance foraging. The behavior component will focus on the realtive impact of synoptic oceanographic features (e.g., fronts) vs. site fidelity (i.e., returning to known feeding grounds) in determining habitat utilization and foraging success.

In addition to the sea lion bioenergetics and behavior implementation, the ecosystem model is currently being run in fully-coupled mode (i.e., ROMS+NEMURO+Fish IBM) to quantify seasonal and interannual variability in biomass distributions for two small coastal pelagic fish species (sardines and anchovies). These two forage fish species will serve as prey items for California sea lions once their bioenergetics and behavior has been added to the ecosystem model. Overall, despite the late start for the project, modelling efforts are on track to achieve the main objectives for Year 1, namely:

1) Additional evaluation of ROMS, NEMURO and IBM for forage fish component.
2) Implementation of California sea lion IBM, including bioenergetics and behavior.
3) Aggregation of physical and biological observations and TOPP data.

RESULTS

Due to the late start of the project (1 September 2012), no significant results are reported for the first fiscal year of the award.

IMPACT/APPLICATIONS

Due to the late start of the project (1 September 2012), no significant impact/applications are reported for the first fiscal year of the award.

RELATED PROJECTS

PI Fiechter and co-PIs Edwards and Moore are collaborating on an NSF-funded project (PI Moore; award dates: 04/01/2011-03/31/2014) entitled: “Variability of the California Current System Derived from 4D-Var Circulation Estimates”. Our current ONR project will benefit from the 4D-Var circulation estimates to improve the accuracy with which the integrated ecosystem model reproduces environmental variability in the California Current (e.g., temperature, phytoplankton). The 4D-Var work will also inform our proposed research on which aspects of seasonal and interannual variability may not be adequately reproduced by ROMS without use of data assimilation.